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Monolithic lithium disilicate complete single crowns with feather-edge preparation design in the posterior region: A multicentric retrospective study up to 12 years

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Objective: This retrospective study evaluated the clinical success and survival of monolithic lithium disilicate single crowns in the posterior region fabricated with feather-edge margins and cemented with resin-based self-etching cement. **Method and Materials:** In total, 627 pressed monolithic lithium disilicate restorations on posterior teeth (110 first premolars, 151 second premolars, 240 first molars, 121 second molars, 5 third molars) were placed in 335 patients. All teeth were prepared with feather-edge margins and restored with single crowns. The modified California Dental Association criteria were used to clinically evaluate subjects during regular maintenance recalls. **Results:** The mean follow-up time was 48.17 months (SD, 27.7; range, 6 to 144). Nine crowns were replaced during the follow-up period due to bulk fracture of the material (overall 97.93% survival rate), and four teeth were extracted. No other technical or biologic failure was observed. **Conclusion:** In this retrospective evaluation, monolithic lithium disilicate crowns with feather-edge margins yielded clinical outcomes similar to those reported with other margin designs and materials. Following the same clinical protocol, crowns on second molars showed lower survival rates when compared to restorations on other teeth in the posterior region. Careful evaluation is mandatory in high-risk patients and terminal teeth. Alternative restorative materials, such as full-contour zirconia crowns, should be considered for the restoration of second molars. *(Quintessence Int 2017;48:601–608; doi: 10.3290/j.qi.a38678)*

Key words: feather-edge, knife-edge, lithium disilicate, minimally invasive preparations, posterior single crowns

The main objective of a tooth preparation procedure is to remove diseased and/or healthy tooth structure and to shape a tooth to receive a restoration. The amount of structure reduction is a function of the restorative material chosen, and the specific clinical situation. It must allow sufficient space to develop adequate mechanical strength of the final restoration, an acceptable occlusal morphology, and pleasing esthetics.[1-4]

Over the past half century, single crowns in the posterior region have evolved from a monolithic form (for example a gold crown) to a bilayered design (metal-ceramic and zirconia-ceramic) to obtain a more natural-looking appearance. Bilayered restorations usually have a strong substructure of metal (or more recently zirconia), which is veneered with ceramic to allow esthetics and function. If fabricated properly, bilayered restorations can function for many years,[5-7] but they have inherent weaknesses. Both the bond between

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substructure (or core) and the esthetic veneering layer, as well as the esthetic ceramic itself, are much less mechanically resistant than the underlying core. Mechanical failure can occur if excessive shear or compressive mechanical force is applied, and is mainly represented by chipping or cracking of the esthetic layer, especially for zirconia-ceramic restorations.[8-10]

The fabrication of monolithic crowns, which are made of a single tooth-colored material, seems to bring a few advantages over more traditional bilayered restorations. The need for a weaker but more esthetic layer of porcelain over an opaque core is eliminated, making the crown much stronger. The amount of space required varies slightly depending on the detail of occlusal morphology expected in the outcome, but in general terms the required thickness for a monolithic restoration is less than the amount required for a bilayered design. The preparation can therefore be more conservative, with a design similar to that of a full-cast gold crown.

It is possible to further reduce invasiveness by using a high-strength ceramic material in combination with a minimal preparation design.[11-13] One possible margin geometry has no visible margin identifiable on the cavosurface finish of the abutment, and is usually named feather-edge. These preparations are a less aggressive alternative to a horizontal margin (such as shoulder or chamfer), and have been used in combination with metal margins for many years. Despite the obvious esthetic limitations related to the visible metal, very good long-term clinical results are reported in the literature.[14-16]

Besides a few technical advantages such as easier impression and good marginal fit, feather-edge preparations can help spare healthy enamel, dentin, and cementum in the cervical region, with potential benefits for the long-term prognosis of the restoration.[14-20] The removal of less tooth structure may be helpful for avoiding pulpal damage in vital teeth, and contributes to stress reduction in endodontically treated teeth. For example, minimally invasive preparations in the cervical region of a tooth with a post-retained core facilitate preserving parallel walls of dentin that extend coronally. In this case, the restoration margins can be placed along the dentin walls, allowing the restoration to encompass the root or crown of a tooth, providing a protective effect known as the "ferrule effect."[21]

Recent advances in the field of dental material science have led to the introduction of high-strength ceramic materials, such as a modified lithium disilicate material that can be used in full-contour restorations for the fabrication of single crowns in the posterior region.[22-25]

Lithium disilicate is available in a variety of opaque and translucent ingots and blocks that allow the technician to optimize the esthetic results through the translucency of the material and the addition of stains. In-vitro testing of this material suggested that monolithic lithium disilicate restorations can be more fatigue-resistant than veneered zirconia.[26-31] Clinical testing has also shown promising results in terms of short- to medium-term survival rates, esthetic outcome, and wear-friendliness to opposing enamel.[32-38]

The use of feather-edge preparations with monolithic lithium disilicate crowns has already been reported in the literature, and has proven to be clinically effective.[32-38] The type of cement used does not (at least in the short to medium term) seem to negatively affect clinical survival rates,[38-40] or in-vitro strength,[41] although in-vitro studies have shown monolithic lithium disilicate crowns cemented with luting composite showed higher failure load compared with conventional cementation with glass-ionomer cement.[27]

In this retrospective study the authors conducted a nonrandomized, multicentric retrospective clinical trial to evaluate the clinical performance of the pressable lithium disilicate glass-ceramic material utilized in single-tooth restorations with feather-edge preparations, cemented with self-adhesive resin-based cement.

METHOD AND MATERIALS

This study reports clinical results for 627 monolithic lithium disilicate single crowns with feather-edge margins placed in 335 patients by four clinicians working in separate dental practices (DC, SG, JS, MV) between January 2004 and July 2015. The distribution of crowns by tooth position and number of patients are reported

Table 1 Distribution (molar or premolar) and number of patients of the included posterior crowns

Year	Patients (n)	1st premolar	2nd premolar	1st molar	2nd molar	3rd molar	Crowns/Y
2004	1	0	1	1	1	0	3
2005	2	1	0	0	1	0	2
2006	8	1	5	6	0	0	12
2007	5	0	3	2	0	0	5
2008	20	10	13	26	13	1	63
2009	31	13	19	21	9	0	62
2010	50	17	21	44	15	0	97
2011	66	15	23	34	19	0	91
2012	31	12	10	20	14	3	59
2013	42	13	20	31	14	0	78
2014	33	15	13	25	18	0	71
2015	46	13	23	30	17	1	84
Total	335	110	151	240	121	5	627

Table 2 Clinical rating of restorations using CDA modified criteria[42,43]

Parameter	Rating	Definition
Color match	Alpha	No mismatch in color, shade, or translucency between restoration and adjacent teeth
	Bravo	Mismatch between restoration and adjacent teeth within the normal range of tooth color, shade, or translucency
	Charlie	Evident color discrepancy with esthetically displeasing color, shade, or translucency
Restoration surface	Alpha	Smooth surface (that becomes shiny after air drying)
	Bravo	Dull surface or minor chipping of porcelain that does not impair esthetics or function and does not expose tooth structure
	Charlie	Chipping that impairs esthetics/function, or exposes tooth structure; cracks or fissures detectable with an explorer tip within the bulk of the material
Marginal discoloration	Alpha	No discoloration of the margin
	Bravo	Superficial marginal discoloration that does not penetrate in the direction of the pulp
	Charlie	Discoloration that penetrates in a pulpal direction
Marginal integrity	Alpha	No visible evidence of crevice along the margin; there is no catch or penetration of the explorer
	Bravo	Visible evidence of crevice or catch of the explorer along the margin; the explorer does not penetrate
	Charlie	Visible evidence of crevice along the margin with penetration of the explorer tip
	Delta	Restoration is visibly fractured, has become loose, or is completely missing

in Table 1. All the crowns were fabricated with hot pressed lithium disilicate. Every patient followed a personalized maintenance program, with scheduled recalls every 3 to 6 months depending on their periodontal status. During the scheduled maintenance appointments between September 2015 and June 2016, the integrity of restoration structure (presence or absence of chips, cracks, fractures) and clinical marginal seal were evaluated by visual inspection and with a sharp dental explorer. The crowns were clinically evaluated using modified California Dental Association (CDA) criteria (Table 2).[42,43] Data for color match, porcelain sur-

Table 3 Mean follow-up times, range, and standard deviation (SD)

	1st premolar	2nd premolar	1st molar	2nd molar	3rd molar	All crowns
Number of teeth (n)	110	151	240	121	5	627
Range (mo)	6–127	6–144	6–144	6–144	8–87	6–144
Mean (mo)	46.84	50.71	49.31	45.45	42.60	48.17
SD (mo)	26.45	28.75	27.71	27.28	28.37	27.72

Table 4 Failure type and complications (biologic and technical), cumulative survival rates (CSR), and success rates (SR) for each group (second and third molar data were pooled)

Parameter		1st premolar	2nd premolar	1st molar	2nd + 3rd molars	All crowns
Failure (n)	Non-repairable chipping	0	0	1	1	2
	Material fracture	0	0	1	6	7
	Caries of the abutment	0	0	0	0	0
	Endodontic failure	0	0	1	0	1
	Tooth fracture	1	0	1	1	3
	Total	1	0	4	8	13
CSR (survival rate, %)		99.09	100.00	98.33	93.65	97.93
Complication (n)	Hypersensitivity	0	1	0	3	4
	Loss of retention	0	0	1	0	1

face, marginal discoloration, and integrity were gathered and evaluated with descriptive statistics. The estimated survival probability of the crowns was statistically analyzed using the Kaplan-Meier method[44] with MedCalc software v. 12.1 (MedCalc). The survival time was defined as the period starting at baseline and ending when the clinician estimated that an irreparable failure of the crown had occurred. Whenever possible (if the tooth did not need to be extracted), the failed crown was replaced with a new one.

The clinical protocol followed by the four clinicians has already been described in detail elsewhere.[32,33,38]

In brief, all clinicians prepared teeth with a feather-edge margin geometry using the same armamentarium. The teeth were reduced by at least 1 mm along the axial walls, and approximately 0.3 mm at the margins with 862 shape diamond burs (862.12, 862.16, 8862.12; Brasseler-Komet), with a slight convergence angle of about 6 to 10 degrees and a 1.5-mm reduction at the occlusal surface. The finish line was placed juxtagingivally or up to 1 mm apical to the free gingival margin. The restorations were cemented with self-etching, self-adhesive resin cement (Rely-X Unicem 2, 3M Espe; or Multilink, Ivoclar) using the split dam technique or cotton rolls for isolation.

RESULTS

The mean follow-up time for all crowns calculated through descriptive statistics was 48.17 months (SD, 27.7; range, 6 to 144) as reported in Table 3. Failure types, complications, and cumulative survival rates are shown in Table 4. Out of the initial 627 crowns on 134 vital and 493 endodontically treated teeth entering this study, 13 were classified as failures. Two of these (15.4%) were recorded in vital teeth, and 11 (84.6%) in endodontically treated teeth.

The following criteria were considered for the definition of crown failure:

- fracture of the material
- major chipping that was not repairable by composite material
- caries of the abutment tooth
- tooth loss because of biologic complications (eg, fracture of abutment tooth, endodontic failure).

In case of any mechanical complication, the restoration was always considered a failure. A total of 9 crowns fractured during the study after 3 to 84 months. Four teeth were extracted: three teeth fractured and one experienced untreatable endodontic problems. Therefore, at the time of clinical evaluation, 614 of the initial 627 crowns were available for evaluation.

Biologic complications such as loss of vitality and/or endodontic disease, and technical complications such as loss of retention or minor chipping (polishable or repairable with composite) were not considered failures if the crown did not need replacement.

No caries of the abutment teeth was observed. Five minor complications that did not imply remake of the crowns were also recorded. One loss of retention was observed, and in four cases a small access hole was opened to allow endodontic treatment due to hypersensitivity. The crown margins of the cavities were etched with 5% hydrofluoric acid, a silane coupling agent was applied, and the cavities were filled with composite. These five crowns remained in function, and were not considered failures.

According to the Kaplan-Meier survival analysis method, the overall survival probability was 97.93% up to 12 years (Fig 1) and the estimated mean survival 138.84 months.

Results of the clinical rating of the monolithic crowns are reported in Table 5. Color match was rated excellent for 531 crowns, and good for 81, while two crowns were rated insufficient (Charlie) but were subjectively evaluated as acceptable for the patients. Surface and anatomic form was rated excellent for 546 crowns; 68 crowns showed minor wear or a dull appearance that could be polished chairside; 567 crowns were rated excellent for marginal discoloration and 585 for marginal integrity. Color match was the lowest rating recorded, with 86.48%. Marginal integrity was the highest, at 95.29%.

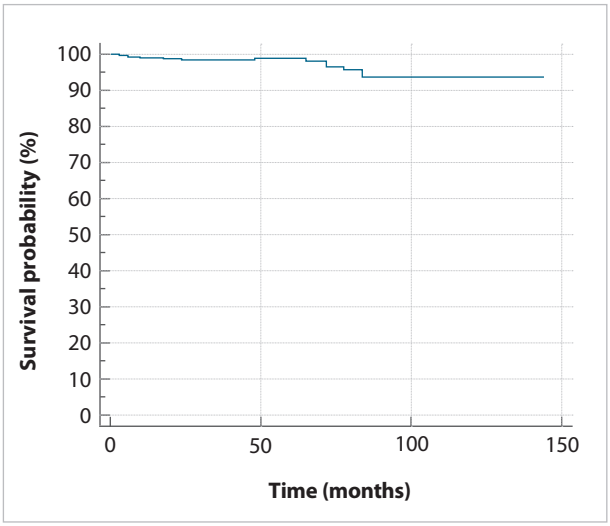

Fig 1 Survival curve for lithium disilicate restorations.

DISCUSSION

In this study, monolithic lithium disilicate single crowns with feather-edge margin geometry on posterior teeth were associated with very high medium-term success rates (close to 98%) up to 12 years of clinical service, with an average follow-up of 48 months.

These results are comparable to data previously reported on monolithic lithium disilicate crowns with feather-edge margin design, which have shown very good survival rates, with few technical complications.[32,33,38] There are, however, limited clinical data available regarding medium- to long-term survival of this type of restoration.[32-40]

Like for other dental ceramic materials, some authors have expressed concern regarding the formation and propagation of subcritical cracks with time due to the brittle nature of this material. Pre-existing subcritical defects within the material may be induced to grow slowly by repeated or prolonged low-level loading until failure occurs, especially in the presence of moisture.[25,31]

Table 5 Frequency distribution of clinical ratings according to the modified CDA criteria

	Modified CDA rating					
	Alpha		Bravo		Charlie	
Parameter	%	n	%	n	%	n
Color match	86.48	531	13.19	81	0.33	2
Restoration surface	88.93	546	11.07	68	0.00	0
Marginal discoloration	92.35	567	7.65	47	0.00	0
Marginal integrity	95.28	585	4.72	29	0.00	0

During aging, a bulk fracture of the material may occur even at a level of loading lower than the one originally needed to cause failure of the restoration.

The findings of the present study do not seem to support a negative effect of aging of the material. Only nine crown fractures were recorded, four of which occurred after 48 months, and the other five within the first 2 years of service (Fig 2). Most of the early failures (three out of five) were recorded within the first year. In addition, the fractures reported in the present study were not evenly distributed among tooth types. More crowns (77.8%) fractured in second molars than in all other posterior teeth combined. This is reflected in a lower survival rate of crowns in the second molar group (93.65%) compared to the higher survival rates calculated for first molars, or premolars, which range from 98% to 100%. Moreover, the nine crown fractures were seen in six patients, with three patients experiencing two failures each. These results seem to suggest that monolithic lithium disilicate crowns are susceptible to mechanical overload and should be used with caution in patients with higher biomechanical risk, such as bruxers, and in the terminal posterior region. Although clinical reports have shown this type of ceramic restoration to be very reliable,[32-40] even at a reduced thickness,[28,29] in these higher risk clinical situations, alternative restorative materials, such as full-contour zirconia crowns or with increased thickness (which would become potentially more invasive) should be considered.

Although feather-edge preparations are not per se recommended by the manufacturer when using monolithic lithium disilicate, the manufacturer states this material can be pressed to a minimum thickness of 0.3 to 0.4 mm. The accepted minimum thickness is therefore roughly compatible with crown thickness at the margin level in the current study, where the material is at its thinnest.

The type of cervical margin design reported in the present study has already been shown to provide excellent clinical results with high-strength ceramic materials such as veneered zirconia and lithium disilicate.[11,12,32,33,38]

In the present study, 627 monolithic crowns with feather-edge preparations placed in a private dental practice setting gave favorable results, similar or superior to other medium-term data reported in the literature with other margin designs and materials. The CDA evaluation has been used in numerous recent studies on the clinical performance of lithium disilicate- and zirconia-based restorations.[11,12,32-34,38,45,46]

According to the CDA evaluation, the clinical quality of virtually all crowns was within the satisfactory range. Patient satisfaction with the crowns was also very high. No caries lesions were detectable and no adverse soft tissue reactions around the crowns were observed. Margin integrity was rated excellent in most crowns. Only two crowns were rated insufficient (Charlie) for color match. In both cases, the final result was negatively influenced by translucency of the material that allowed the strongly pigmented abutment to show through. In addition, most of the Bravo ratings for color match in older crowns were seen in patients where the surrounding teeth seemed to have gradually changed color. In other cases, the dental technicians were not fully able to replicate the exact shade of the existing dentition.

A few limitations of this retrospective study should be considered. Treatment was performed by different clinicians in different private practices, although the same type of margin was prepared with identical burs and clinical procedures. In the dental laboratories, the same ceramic system and technical procedures were used to fabricate the restorations. A direct comparison of the groups of restorations reported was unfortunately not possible, because the number of crowns per patient and group were different and placed at different times. In general, all groups except the second

Fig 2a Case 2, clinical situation of the first quadrant (different case) at the time of impressions.

Fig 2b Case 2, monolithic lithium disilicate single crowns were placed on the maxillary right second premolar and first molar, while the first premolar was restored with an implant-supported metal-ceramic crown.

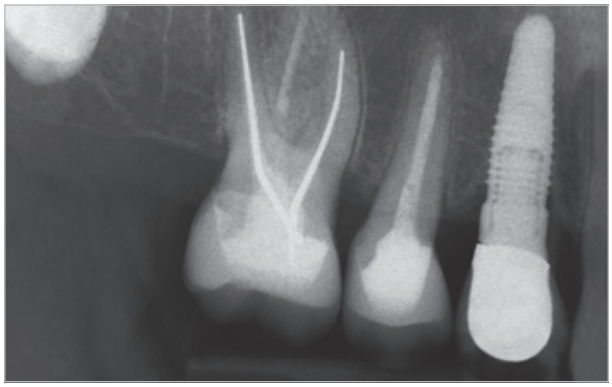

Fig 2c Case 2, postoperative radiograph of the maxillary right second premolar and first molar.

Fig 2d Case 2, occlusal view of failed monolithic crown of maxillary first molar. The crown fractured after 18 months of clinical service (case reported in Table 3).

molars showed a clinically negligible failure rate, as shown in Table 3. The survival rate of the second molar group is comparable to data reported in literature with different materials and margin types, thus can be considered clinically acceptable.

This study reports practice-based clinical data, with related shortcomings and advantages. The results suggest that the clinical performance of monolithic lithium disilicate crowns with feather-edge margins is similar to that reported with other margin designs, although it requires less removal of tooth structure. Existing recommendations to avoid feather-edge margins for lithium disilicate restorations did not negatively influence the clinical results reported, confirming the findings of other studies.[32,33,38] Despite such favorable and encouraging results, longer observation periods and randomized controlled trials are needed to compare the long-term effectiveness of lithium disilicate crowns fabricated with different marginal designs.

CONCLUSION

The results found in this retrospective evaluation suggest that for monolithic lithium disilicate, feather-edge margins yield clinical outcomes similar to that reported with other margin designs and other materials. Crowns on second molars require careful evaluation, as there is an increased possibility of mechanical failure in patients with high biomechanical risk.

ACKNOWLEDGMENT

The authors thank Dr Alessandro Valenti for his assistance in the statistical analysis.

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